SECTION I.—AEROLOGY.

SOLAR AND SKY RADIATION MEASUREMENTS DURING MAY, 1916.

By HERBERT H. KIMBALL, Professor of Meteorology.

[Dated: Washington, D. C., June 15, 1916.]

For a description of instrumental exposures, and an account of the methods of obtaining and reducing the measurements, the reader is referred to the REVIEW for January and April, 1916, 44:2, 179, 180.

On May 11, 1916, the Marvin pyrheliometer at Santa Fe, N. Mex., was removed from the office to a special shelter provided for it on the roof of the building, where exposure to the sun is possible at all hours of the day. In this shelter the pyrheliometer is 7,037 feet or 2,145 meters above sea level.

The monthly means and departures from normal values given in Table 1 show that direct solar radiation averaged below normal at Washington and above normal at Santa Fe and Madison. At the latter station, however, there were few days when clouds were absent for a sufficient length of time to permit pyrheliometric measurements to be made.

A noon maximum of 1.61 gram-calories per minute per square centimeter of normal surface, obtained at Santa Fe on May 4, exceeds any previous May noon reading at that station by 4 per cent.

TABLE 1.—*Solar radiation intensities during May, 1916.*

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
	Gr.-cal.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
Washington, D. C.										
A. M.										
May 1	1.18		0.82							
6	1.34	1.18	0.95	0.78	0.64	0.54				
9	1.04	0.78	0.65	0.55						
10		1.08	0.99	0.83	0.68					
12	1.39	0.99	0.93	0.89						
17		1.23	1.02							
18	1.28	1.20								
19	1.36	1.20	1.15	1.06	0.99	0.93	0.83	0.75		
20	1.29	1.07								
21			1.18	1.03						
25	1.27	0.99								
26	1.26									
28			0.95	0.87						
Monthly means	1.27	1.09	0.96	0.86	0.77	(0.74)	(0.83)	(0.75)		
Departure from 8-year normal	−0.05	−0.07	−0.09	−0.07	−0.07	−0.03	−0.01	+0.05		
P. M.										
May 1		0.99	0.69	0.62	0.56	0.50	0.45	0.41	0.37	0.33
6		0.80	0.67	0.56	0.49					
12		1.16								
19		1.26	1.11							
Monthly means		1.05	0.82	(0.59)	(0.52)	(0.50)	(0.45)	(0.41)	(0.37)	(0.33)
Departure from 8-year normal		−0.11	−0.17	−0.26	−0.23	−0.24	−0.22	−0.20	−0.22	

TABLE 1.—*Solar radiation intensities during May, 1916*—Continued.

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
	Gr.-cal.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
Madison, Wis.										
A. M.										
May 5	1.35	1.34								
7	1.34									
11	1.40									
18	1.42	1.31	1.23							
31	1.33									
Monthly means	1.37	(1.32)	(1.23)							
Departure from 6-year normal	+0.05	+0.11	+0.12							
P. M.										
May 5		1.24								
11		1.33	1.20							
Monthly means		(1.28)	(1.20)							
Departure from 6-year normal		+0.10	+0.24							
Lincoln, Nebr.										
A. M.										
May 1	1.54	1.48	1.36							
3	1.53	1.43	1.35	1.26	1.17	1.08	1.01	0.93		
4	1.41				1.14	1.06	0.99	0.93	0.88	
5		1.34	1.22	1.12	1.04	0.96	0.89	0.79		
7			1.18	1.08	0.98	0.89	0.82	0.74		
8		1.33	1.18	1.04	0.92	0.76	0.64	0.53		
10	1.21	1.17	1.11	0.99	0.88					
17		1.42	1.37	1.27	1.19					
22		1.36	1.28	1.20	1.12	1.04	0.97	0.91		
23	1.41									
24			1.03	0.93	0.85	0.78	0.71			
25	1.39	1.26	1.14	1.01	0.86	0.79	0.72			
28				1.03	0.99	0.91	0.83			
30	1.39	1.24	1.08	0.96	0.87	0.81	0.75			
Means	1.41	1.34	1.21	1.08	1.00	0.91	0.83	0.80	(0.88)	
P. M.										
May 1		1.29		1.18	1.11	1.05	0.97	0.90	0.83	
3			1.19							
4		1.32	1.23							
5		1.32								
6		1.22	1.10							
24		1.11	0.96	0.84	0.73	0.66	0.59			
Means		1.25	1.12	(1.01)	(0.92)	(0.86)	(0.78)	(0.90)	(0.83)	
Santa Fe, N. Mex.										
A. M.										
May 4	1.62	1.52	1.43	1.36	1.30	1.24				
12	1.59	1.47	1.37	1.31	1.19	1.14	1.10	1.05		
13	1.53	1.42	1.33	1.26	1.20	1.17	1.14	1.06		
16	1.60	1.40	1.39	1.36	1.31	1.26	1.20	1.15	1.10	
18	1.51									
19	1.51	1.38	1.31	1.26	1.20	1.15	1.10	1.05	1.01	
22	1.51	1.46	1.40	1.33	1.24	1.21	1.12			
24	1.54	1.46	1.38	1.31	1.24	1.21	1.12			
25	1.58	1.47	1.40	1.34	1.26	1.19	1.16			
26	1.60									
27	1.62	1.50	1.39	1.30	1.24	1.19	1.13			
29	1.53	1.44	1.36	1.29	1.23	1.18	1.13			
Monthly means	1.56	1.45	1.38	1.31	1.24	1.19	1.13	1.08	(1.06)	
Departure from 4-year normal	+0.03	+0.03	+0.05	+0.04	+0.02					
P. M.										
May 15		1.50	1.44	1.37	1.30	1.23	1.17			
16		1.49	1.41	1.35	1.30	1.24				
24		1.39	1.26	1.12	1.11					
25		1.41	1.29	1.25	1.19					
26		1.45	1.38	1.33	1.23					
27			1.37	1.27	1.22					
Monthly means		1.45	1.36	1.28	1.22	(1.24)	(1.17)			

TABLE 2.—*Vapor pressure at pyrheliometric stations on days when solar radiation intensities were measured.*

Washington, D. C.			Madison, Wis.			Lincoln, Nebr.			Santa Fe, N. Mex.		
Date.	8 a. m.	8 p. m.	Date.	8 a. m.	8 p. m.	Date.	8 a. m.	8 p. m.	Date.	8 a. m.	8 p. m.
1916.	*Mm.*	*Mm.*	1916.	*Mm.*	*Mm.*	1916.	*Mm.*	*Mm.*	1916.	*Mm.*	*Mm.*
May 1	7.29	7.87	May 5	6.27	7.57	May 1	4.17	4.57	May 4	3.15	2.39
6	9.47	8.18	7	6.27	12.24	3	4.93	4.57	12	3.99	2.16
9	5.36	6.50	11	4.57	4.17	4	5.36	6.50	13	3.15	1.88
10	7.04	12.21	18	4.37	4.57	5	6.76	7.57	15	1.96	1.12
12	4.57	7.57	31	5.56	9.83	6	9.47	8.18	16	1.78	1.52
17	5.36	4.37				7	10.97	12.24	18	3.45	2.87
18	6.50	5.36				8	6.02	5.16	19	3.00	1.96
19	4.75	6.50				10	4.95	2.49	22	2.87	3.63
20	7.04	7.87				17	6.02	5.56	24	4.57	11.81
21	4.95	5.56				22	9.14	12.24	25	4.17	8.81
25	13.13	13.13				23	8.81	13.61	26	3.81	3.63
26	9.47	10.59				24	14.10	16.79	27	2.87	4.17
28	16.20	16.20				25	10.97	19.89	29	3.30	3.00
						28	10.59	10.21			
						30	10.59	10.97			

On the mornings of May 24, 25, and 29 the readings obtained at Santa Fe indicate quite steady atmospheric conditions throughout the half-day periods. Reduced to mean solar distance of the earth and extrapolated to zero air mass they give solar radiation intensities of 1.76, 1.79, and 1.77, respectively. Employing the vapor pressures given by Table 2 in applying to the above measurements the Smithsonian "Abridged procedure for determining approximately the value of the solar constant",[1] we obtain 1.89, 1.91, and 1.88, respectively, or values but slightly lower than Abbot's mean value for the solar constant.

Skylight polarization measurements at Washington on six days give a mean of 51 per cent, with a maximum of 58 per cent on May 19.

Table 3 shows that at Washington there was a deficiency in the total radiation received during the month amounting to 3.7 per cent of the normal. At Madison there was an excess amounting to 4.2 per cent. Since the first of the year the deficiency at Washington is 7.9 per cent of the average amount, and at Madison the excess is 0.3 per cent.

TABLE 3.—*Daily totals and departures of solar and sky radiation during May, 1916.*

[Gram-calories per square centimeter of horizontal surface.]

Day of month.	Daily totals.			Departures from normal.		Excess or deficiency since first of month.	
	Washington.	Madison.	Lincoln.	Washington.	Madison.	Washington.	Madison.
1916.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
May 1	590	237	739	110	−217	110	−217
2	325	547	353	−157	92	− 47	−125
3	531	360	727	46	− 96	− 1	−221
4	394	550	676	− 94	93	− 95	−128
5	534	658	692	44	200	− 51	72
6	622	249	582	130	−210	79	−138
7	231	669	596	−262	210	−183	72
8	544	704	703	50	244	−133	316
9	600	578	559	105	118	− 28	434
10	495	468	716	− 1	8	− 29	442
11	520	762	294	23	301	− 6	743
12	644	385	88	147	− 76	141	667
13	282	244	85	−216	−217	− 75	450
14	169	133	157	−329	−329	−404	121
15	595	668	535	96	206	−308	327
16	228	261	607	−271	−202	−579	125
17	514	634	639	15	170	−564	295
18	460	690	376	− 39	226	−603	521
19	711	538	179	213	73	−390	594
20	658	394	190	160	− 72	−230	522
Decade departure						−201	80

[1] Annals of the Astrophysical Observatory of the Smithsonian Institution, Washington, 1908, 2:115.

TABLE 3.—*Daily totals and departures of solar and sky radiation during May, 1916*—Continued.

[Gram-calories per square centimeter of horizontal surface.]

Day of month.	Daily totals.			Departures from normal.		Excess or deficiency since first of month.	
	Washington.	Madison.	Lincoln.	Washington.	Madison.	Washington.	Madison.
1916.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
May 21	718	162	410	220	−304	− 10	218
22	315	480	676	−183	13	−193	231
23	102	537	678	−396	69	−589	300
24	252	448	609	−245	− 21	−834	279
25	621	419	693	124	− 51	−710	228
26	636	531	626	140	59	−570	287
27	581	458	621	85	− 17	−485	270
28	534	671	570	39	193	−446	463
29	452	242	662	− 42	−239	−488	224
30	267	732	731	−227	249	−715	473
31	637	615	338	144	130	−571	603
Decade departure						−341	81
Excess or deficiency since first of year. gr.-cal.						−4,057	+128
Excess or deficiency since first of year. per cent.						−7.9	+0.3

CIRCUMHORIZONTAL ARC OBSERVED.

By JULIAN T. GRAY, Assistant Observer.

[Dated: Weather Bureau, Cincinnati, Ohio, June 13, 1916.]

On June 5, 1916, while observing a very bright solar halo of the ordinary type, a phenomenon was noticed which at first was believed to be the lower portion of the great halo of 46°. The arc was 30° or more in extent, concave to the sun, and so situated that its middle point appeared vertically beneath the sun. It was also remarkable for its vivid colors, and in this characteristic it bore a strong resemblance to the "circumzenithal arc," an example of which the writer observed at Ludington, Mich., during the winter of 1913–14.

The fact was at once noticed that the arc appeared flat, i. e., not having that degree of curvature which would be expected of a halo of 46°, and it was not concentric with the halo of 22°. So far as we are able to judge, the arc was parallel to the horizon at an altitude of about 20°, with, perhaps, a slight upward curve at either extremity. It therefore seems reasonably evident that we had to do with the "circumhorizontal arc" or "lower tangent arc of the halo of 46°," concerning which Besson says, "So far, only three or four observations of this arc are known."

The phenomenon remained visible for about 15 minutes after discovery—from 12:50 to about 1:05 p. m. (90th Meridian time). During this period the sky was everywhere visibly covered with thin cirrus or cirro-stratus clouds in which numerous white streaks and patches appeared. We endeavored to make such measurements as were possible without instrumental equipment, which, though lacking in that degree of accuracy which would be desirable, are presented with the belief that the possible limits of error in either direction are such that the results obtained may be of some value.

A piece of cardboard in which a pin was stuck perpendicularly at the end of a black line served as a sort of sextant, by means of which our measurements were made. The angles were plotted on the cardboard and measured with a protractor. The measurement was taken in each case from a point as near the middle of the band or ribbon of light as could well be judged.

The radius of the ordinary halo as measured was exactly 22½°, which, considered as a check, may indicate that the other measurements made by the same method